Claims

1. A multi-carrier communication system comprising:

a transmitter comprising:

a data input for receiving an unknown data signal for transmission;

a known data input for receiving a known data signal;

a signal power ratio input for receiving a power ratio signal indicating a ratio for combining the unknown data signal and the known data signal; and

a data combiner coupled to the data input, the known data input and the signal power ratio input, the data combiner for combining the unknown data signal and the known data signal in accordance with the power ratio signal to produce a composite output signal comprising discrete data signals, wherein each discrete data signal comprises at least a portion of the unknown data signal and at least a portion of the known data signal combined in accordance with the power ratio signal, the data combiner having an output adapted to provide the composite output signal to a multi-carrier transmitter, wherein the multi-carrier transmitter transmits a transmit signal on a communication channel, wherein the transmit signal includes the composite output signal; and

a receiver comprising:

a multi-carrier receiver for receiving a receive signal corresponding to the transmit signal on the communication channel, and the multi-carrier receiver having an output for providing a corresponding composite signal, wherein the corresponding composite signal comprises corresponding discrete data signals, and the corresponding composite signal being shaped by at least one signal shaping characteristic of the communication channel;

a channel estimator having a known data input for receiving the known data signal, an input coupled to receive the corresponding composite signal, an input coupled to receive the power ratio signal, and an input for receiving at least one estimate of the unknown data signal, the channel estimator for estimating the at least one signal shaping characteristic of the communication channel from at least the corresponding composite signal, the at least the portion of the known data signal of at least some of the corresponding discrete data signals, the power ratio signal and the at least one estimate of the unknown data signal, and the channel estimator having an output for providing at least one estimated communication channel characterizing signal; and

an equalizer coupled to receive the corresponding composite signal, the known data signal, the power ratio signal and the at least one estimated communication channel characterizing signal, the equalizer for configuring at least one of its signal shaping characteristics to compensate for the at least one signal shaping characteristic of

the communication channel, the configured equalizer for shaping the corresponding composite signal accordingly, and the equalizer having an output for providing at least one subsequent estimate of the unknown data signal.

2. A multi-carrier communication system in accordance with claim 1 wherein the data combiner further comprises:

a data conditioner coupled to receive the unknown data signal and the power ratio signal, the data conditioner for changing the power level of the unknown data signal substantially in accordance with the power ratio signal, and the data conditioner being adapted to provide a conditioned unknown data signal;

a pilot conditioner coupled to receive the known data signal and the power ratio signal, the pilot conditioner for changing the power level of the known data signal substantially in accordance with the power ratio signal, and the pilot conditioner being adapted to provide a conditioned known data signal; and

an adder coupled to receive the conditioned unknown data signal and the conditioned known data signal, for combining the conditioned unknown data signal and the conditioned known signal, and the adder coupled to provide the discrete data signals.

3. A multi-carrier communication system in accordance with claim 1 further comprising a memory for storing the known data signal, and the memory being coupled to provide the known data signal to the channel estimator and the equalizer.

4. A multi-carrier communication system in accordance with claim 1 further comprising a memory for storing the power ratio signal, and the memory being coupled to provide the power ratio signal to the channel estimator and the equalizer.

5. A multi-carrier communication system in accordance with claim 1 wherein the multi-carrier transmitter comprises a serial to parallel converter having an input coupled to the output of the data combiner, and having a plurality of outputs for providing a plurality of sub-composite signals.

6. A multi-carrier communication system in accordance with claim 5 wherein the multi-carrier transmitter further comprises a multi-channel modulator having a plurality of inputs coupled to the plurality of outputs of the serial to parallel converter, the multi-channel modulator for modulating each of the plurality of sub-composite signals on at least one of the plurality of sub-carrier signals, and the multi-channel modulator having a plurality of outputs for providing the plurality of modulated sub-carrier signals.

7. A multi-carrier communication system in accordance with claim 6, wherein the multi-channel modulator comprises an inverse discrete Fourier transform module.

8. A multi-carrier communication system in accordance with claim 6 wherein the multi-carrier transmitter further comprises a parallel to serial converter having a plurality of inputs coupled to the plurality of outputs of the multi-channel modulator, and having a data output for providing a serial data signal.

9. A multi-carrier communication system in accordance with claim 8 wherein the multi-carrier transmitter further comprises a cyclic prefix adder having an input for receiving the serial data signal, the cyclic prefix adder for adding at least one predetermined data prefix to the serial data signal to produce the transmit signal, and having an output for providing the transmit signal on the communication channel.

10. A multi-carrier communication system in accordance with claim 1 wherein the multi-carrier receiver comprises a cyclic prefix remover having an input coupled to receive the receive signal on the communication channel, the cyclic prefix remover for removing the at least one predetermined data prefix from the receive signal, and the cyclic prefix remover having an output for providing a corresponding serial data signal.

11. A multi-carrier communication system in accordance with claim 10 wherein the multi-carrier receiver further comprises a serial to parallel converter having an input for receiving the corresponding serial data signal, and having an output for providing a plurality of modulated sub-carrier signals.

12. A multi-carrier communication system in accordance with claim 11 wherein the multi-carrier receiver further comprises a multi-channel demodulator having a plurality of inputs for receiving the plurality of modulated sub-carrier signals and having a plurality of outputs for providing a plurality of sub-composite signals.

13. A multi-carrier communication system in accordance with claim 12 wherein the multi-channel demodulator comprises a discrete Fourier transform module.

14. A multi-carrier communication system in accordance with claim 13 wherein the multi-carrier receiver further comprises a parallel to serial converter having a plurality of inputs for receiving the plurality of sub-composite signals, and having an output for providing the corresponding composite signal.

15. A multi-carrier communication system in accordance with claim 1 wherein at least part of the channel estimator and at least part of the equaliser comprise a 2-D Weiner filter.

16. A multi-carrier transmitting system comprising:

a data input for receiving an unknown data signal for transmission;

a known data input for receiving a known data signal;

a signal power ratio input for receiving a power ratio signal indicating a ratio for combining the unknown data signal and the known data signal; and

a data combiner coupled to the data input, the known data input and the signal power ratio input, the data combiner for combining the unknown data signal and the known data signal in accordance with the power ratio signal to produce a composite output signal comprising discrete data signals, wherein each discrete data signal comprises at least a portion of the unknown data signal and at least a portion of the known data signal combined in accordance with the power ratio signal, the data combiner having an output adapted to provide the composite output signal to a multi-carrier transmitter, wherein the multi-carrier transmitter transmits a transmit signal on a communication channel, wherein the transmit signal includes the composite output signal.

17. A multi-carrier communication system in accordance with claim 16 wherein the data combiner further comprises;

a data conditioner coupled to receive the unknown data signal and the power ratio signal, the data conditioner for changing the power level of the unknown data signal substantially in accordance with the power ratio signal, and the data conditioner being adapted to provide a conditioned unknown data signal;

a pilot conditioner coupled to receive the known data signal and the power ratio signal, the pilot conditioner for changing the power level of the known data signal substantially in accordance with the power ratio signal, and the pilot conditioner being adapted to provide a conditioned known data signal; and

an adder coupled to receive the conditioned unknown data signal and the conditioned known data signal, for combining the conditioned unknown data signal and the conditioned known signal, and the adder coupled to provide the each discrete data signals.

18. A multi-carrier transmitting system in accordance with claim 16 wherein the data combiner comprises a frequency domain data combiner for adding the varying data signal and the known data signal in the frequency domain.

19. A multi-carrier transmitting system in accordance with claim 18 wherein the frequency domain data combiner is adapted to provide an output signal thus:

$$x_F(n,l)=d_F(n,l)+p_F(n,l), \qquad \forall(n,l)\in S$$

20. A multi-carrier transmitting system in accordance with claim 16, wherein the multi-carrier transmitter further comprises a serial to parallel converter having an input coupled to the output of the data combiner, and having a plurality of outputs for providing a plurality of sub-composite signals.

21. A multi-carrier transmitting system in accordance with claim 20 wherein the multi-carrier transmitter further comprises a multi-channel modulator having a plurality of inputs coupled to the plurality of outputs of the serial to parallel converter, the multi-channel modulator for modulating each of the plurality of sub-composite signals on at least one of the plurality of sub-carrier signals, and the multi-channel modulator having a plurality of outputs for providing the plurality of modulated sub-carrier signals.

22. A multi-carrier transmitting system in accordance with claim 21, wherein the multi-channel modulator comprises an inverse discrete Fourier transform module.

23. A multi-carrier transmitting system in accordance with claim 21 wherein the multi-carrier transmitter further comprises a parallel to serial converter having a plurality of inputs coupled to the plurality of outputs of the multi-channel modulator, and having a data output for providing a serial data signal.

24. A multi-carrier transmitting system in accordance with claim 23 wherein the multi-carrier transmitter further comprises a cyclic prefix adder having an input for receiving the serial data signal, the cyclic prefix adder for adding at least one predetermined data prefix to the serial data signal to produce the transmit signal, and having an output for providing the transmit signal on the communication channel.

25. A multi-carrier receiving system comprising:

a multi-carrier receiver for receiving a receive signal on a communication channel, where in the receive signal includes a composite signal, and the multi-carrier receiver having an output for providing the composite signal, wherein the composite

signal comprises discrete data signals, and wherein each discrete data signal comprises at least a portion of an unknown data signal and at least a portion of a known data signal combined in accordance with a signal power ratio signal, the composite signal being shaped by at least one signal shaping characteristic of the communication channel;

a channel estimator having a known data input for receiving the known data signal, an input coupled to receive the composite signal, an input coupled to receive the power ratio signal, and an input for receiving at least one estimate of the unknown data signal, the channel estimator for estimating the at least one signal shaping characteristic of the communication channel from at least the composite signal, the at least the portion of the known data signal of at least some of the discrete data signals, the power ratio signal and the at least one estimate of the unknown data signal, and the channel estimator having an output for providing at least one estimated communication channel characterizing signal; and

an equalizer coupled to receive the composite signal, the known data signal, the power ratio signal and the at least one estimated communication channel characterizing signal, the equalizer for configuring at least one of its signal shaping characteristics to compensate for the at least one signal shaping characteristic of the communication channel, the configured equalizer for shaping the composite signal accordingly, and the equalizer having an output for providing at least one subsequent estimate of the unknown data signal.

26. A multi-carrier communication system in accordance with claim 25 further comprising a memory for storing the known data signal, and the memory being coupled to provide the known data signal to the channel estimator and the equalizer.

27. A multi-carrier communication system in accordance with claim 25 further comprising a memory for storing the power ratio signal, and the memory being coupled to provide the power ratio signal to the channel estimator and the equalizer.

28. A multi-carrier receiving system in accordance with claim 25 wherein the multi-carrier receiver comprises a cyclic prefix remover having an input coupled to receive the receive signal on the communication channel, the cyclic prefix remover for removing at least one predetermined data prefix from the receive signal, and the cyclic prefix remover having an output for providing a corresponding serial data signal.

29. A multi-carrier communication system in accordance with claim 28 wherein the multi-carrier receiver further comprises a serial to parallel converter having an input for

receiving the corresponding serial data signal, and having an output for providing a plurality of modulated sub-carrier signals.

30. A multi-carrier communication system in accordance with claim 29 wherein the multi-carrier receiver further comprises a multi-channel demodulator having a plurality of inputs for receiving the plurality of modulated sub-carrier signals and having a plurality of outputs for providing a plurality of sub-composite signals.

31. A multi-carrier communication system in accordance with claim 30 wherein the multi-channel demodulator comprises a discrete Fourier transform module.

32. A multi-carrier communication system in accordance with claim 30 wherein the multi-carrier receiver further comprises a parallel to serial converter having a plurality of inputs for receiving the plurality of sub-composite signals, and having an output for providing the corresponding composite signal.

33. A multi-carrier communication system in accordance with claim 25 wherein at least part of the channel estimator and at least part of the equaliser comprise a 2-D Weiner filter.

34. A method for determining received data in a multi-carrier communication system, wherein a received signal includes a composite signal received on a communication channel having transmission characteristics, wherein the composite signal comprises a plurality of discrete data signals spaced in time and frequency, and wherein each discrete data signal comprises a data portion and a pilot portion, wherein the data portion comprises one of a predetermined group of symbols, the method comprising the steps of:

a) defining a set of the plurality of discrete data signals;

b) setting a predetermined number of iterations;

c) receiving the composite signal on the communication channel;

d) selecting one of the plurality of discrete data signals to be estimated;

e) selecting a group of the plurality of discrete data signals, wherein each discrete data signal of the group of the plurality of discrete data signals is relevant to determining the one of the plurality of data signals;

f) normalising the group of the plurality of discrete data signals using at least the pilot portion of the one of the plurality of discrete data signals;

g) estimating the transmission characteristics of the communication channel using the normalised group of the plurality of discrete data signals in step (f); and

h) estimating the data portion of the one of the plurality of discrete data signals using the communication channel having the transmission characteristics estimated in step(g) and at least the pilot portion of the one of the plurality of discrete data signals.

35. A method in accordance with claim 34 further comprising the step of:

i) deciding which symbol of the predetermined group of symbols is received from the estimated data portion of the one of the plurality of discrete data signals in step (h).

36. A method in accordance with claim 35 further comprising the step of:

j) determining whether the data portion of all of the group of the plurality of discrete data signals have been determined.

37. A method in accordance with claim 36 further comprising the step of:

k) when the determination in step (j) is not true, selecting another of the plurality of discrete data signals to be determined and repeating steps (e) to (j).

38. A method in accordance with claim 37 further comprising the step of:

l) repeating step (k) until the decision in step (j) is true.

39. A method in accordance with claim 37, further comprising in each iteration of steps (e) to (j), the step of:

m) using the estimated data portion from at least one previous iteration in step (g) to estimate the transmission characteristics of the communication channel.

40. A method in accordance with claim 36 further comprising, when the data portion of all of the group of the plurality of discrete data signals have been determined, the step of:

n) determining whether the predetermined number of iterations set in step (b) have been completed.

41. A method in accordance with claim 40 further comprising, when the predetermined number of iterations set in step (b) have not been completed, the step of:

o) repeating steps (d) to (n) until the predetermined number of iterations have been completed.